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GLASS CONDITIONING
THE PATH TO PERFECT GLASS

There is a direct relationship between glass conditioning and production. For optimal results the correct glass conditioning system has to be chosen.

In the majority of cases such systems comprise of the distributor (working end) and the forehearth. It is now widely accepted that these should be considered as a single glass conditioning system, with the initial work being done in the distributor – a concept that SORG® pioneered in the 1980s with the introduction of the AMC forehearth and Precon working end designs.

Since 1976 SORG® has delivered over 1750 glass conditioning systems. A significant milestone for the leading supplier of these systems. In 2006 we took over the entire Emhart Glass forehearth program and have been able to establish this system in an already crowded segment. From 2009, we have combined the Emhart Glass and SORG® forehearth programs to produce the 340S forehearth, which represents an unbeatable combination of glass conditioning technology from two of the world’s leading suppliers.

SORG® also delivers auxiliary equipment. These add-on systems include forehearth boosting, CONTI-DRAIN®, coloring cells, stirrer units and the patented OMT system.

We have experience with almost all commercial glasses used for the production of containers, tableware, stemware, insulating fiber, textile fiber, lighting ware, tubing, rolled plate, insulators, lenses and other products.
STW – DISTRIBUTERS

INNOVATION IN 3RD GENERATION

SORG® pioneered the concept of using the working end or distributor as part of the glass conditioning system with the introduction of the original Precon design in 1986. Now in the third generation, and therefore fittingly referred to as the STW series (Sorg Third generation Working end) the current designs continue to fulfil this important function.

Heat removal from the glass bath is the most important contribution of the working end to the glass conditioning process, and it is this requirement that generally has an important influence on the design of the working end. Heat removal is carried out through the glass bath surface, and so a wide channel is advantageous wherever cooling is to be applied. A shallow bath depth eases heat transfer within the glass bath and also assists the cooling.

However, these factors can also affect glass flow patterns, which must be treated carefully to avoid problems of stagnating glass. Distributor design is perhaps more critical than may be immediately obvious.

ADVANTAGE

- High capacity heat removal
- Exact control of forehearth entry temperatures
COOLING SYSTEMS
In many cases it is important to remove energy in the distributor, but it may not be necessary to pay too much attention to the thermal homogeneity of the glass, as this can be improved in the forehearth. This has a profound influence on the cooling systems applied in the distributor.

Direct air cooling is often used in the central area around the riser of SORG® STW distributors. In this area glass temperatures are often high enough to ensure that there is no risk of overcooling the glass at the sides of the channel, and so the complete roof area can be used for cooling. Open radiation cooling can be applied in the outer areas of distributors to remove as much energy as possible before the glass enters the forehearths. However, the flexible SORG® approach to cooling, involving the use of all three cooling types, means that the best system can be chosen for each location, to maximise the advantages and minimise any disadvantages.

GAS HEATING
All SORG® distributors utilise the VMC gas heating system described on page 12. Although split left/right heating and control can be provided it is usually not necessary in distributors.

TEMPERATURE MEASUREMENT
Temperature measurement is typically by immersed thermocouples installed vertically through the roof refractory.

CONTROL ZONES
The distributor is normally split up into a number of separate control zones. On a typical installation there will be one zone in the central area around the riser and one zone for each forehearth entry, but this arrangement may not be possible if the forehearth entries are unusually close together. In such a case there may be two forehearth entries in one zone. Alternately, if the forehearth entries are unusually far apart, it may be necessary to have an intermediate zone without a forehearth entry.
One of the most important principles of the STF forehearth is the extremely flexible application of different technologies. For example, four different cooling technologies can be utilized to achieve the optimal solution for each individual zone. On some systems all four cooling systems are applied to different areas. STF-Forehearths are built in all lengths and in channel widths from 16” to 54”. STF-forehearths are normally gas fired. These include the well-known and proven SORG® VMC combustion system. The shape of the superstructure conforms to the most important function of each zone. Therefore, the superstructure is different for the heating and cooling zones.

**STF/E ALL ELECTRIC FOREHEARHTHS**

These are heated through molybdenum electrodes inserted into the glass bath or through electrical heating elements above the glass bath. Even better control and homogeneity are possible than with conventionally heated forehearths. This is especially true with colored glasses. The energy consumption is also significantly lower than with gas fired forehearths.

**THE STF-FOREHEARTHS SERIES OFFER THE FOLLOWING ADVANTAGES:**

- Greater cooling capacity. The consistent application of open radiation cooling leads to high cooling capacity.
- The following factors actively improve the thermal homogeneity through:
  - Higher cooling capacity
  - Left right trimming (optional)
  - Stepping control for cooling systems
- Flexibility: The flexible concept for the STF series offers the optimal solution for each application. There are multiple cooling systems available as well as the possibility to expand the standard design through add-ons.
When producing high quality flint glass, heating elements above the glass bath are often chosen. This avoids foreign materials from coming into contact with the glass. Even this indirect system consumes less energy than gas forehearths. In the past forty years SORG® has built many forehearths for a diverse array of applications.

In addition, these can be expanded on with a number of add-ons.
- Electrical boosting for equalizing zones
- Left / right trimming for gas combustion
- CONTI-DRAIN® to reduce zircon cat scratches.

**SPECIAL FOREHEARTHS**

SORG® delivers custom solutions for individual production needs. For this we have built a number of special forehearths.

**ENCLOSED FOREHEARTHS**

Closed forehearths to avoid streaks. Certain commercial glasses, such as lead crystal glass, include components which volatilise very easily from the glass surface, leaving a layer of glass on the surface which has a different chemical composition to the base glass. The differing glass may appear in the final product as a cord and can, in some circumstances, make production impossible. It is very difficult to remove the cord by stirring, and so the best way of preventing the problem is to stop the volatilisation by enclosing the surface so that the glass effectively flows through a refractory tube. This type of forehearth is usually heated indirectly by means of either radiant electric heating elements or standard gas heating, installed above the top of the refractory tube. This means that the heating effect must be transmitted through the refractory, which results in a heating system which is slow to react. Therefore, in some glasses immersed electrodes may also be provided to give direct heating, which reacts very quickly to changes in the power input. Temperature measurement in covered channels is by thermocouples immersed in the glass bath.

**OVERFLOW DRAINS**

An overflow drain can be used to remove glass from a working end or forehearth. This may be necessary to maintain a stable melting load, or to remove poor quality surface glass. It consists of a short length of forehearth channel, which ends in a conventional spout arrangement, and the glass is removed through a normal orifice ring. SORG® has delivered a variety of overflows and is happy to develop customer specific units.
On 1st July 2006 the complete Emhart Glass forehearth program was transferred to SORG® along with all rights and responsibilities. Since then, over 250 systems have been delivered for all of the normal glass colors up to 200 tons of glass per forehearth.

We deliver more than equipment; we supply the service necessary to keep equipment running optimally. The then already existing SORG® STF forehearth systems still exist as a separate product.

**ADVANTAGES**

- Mature technology
- Excellent thermal homogeneity
In 2009 we combined features of the Emhart Glass 340 and the SORG® STF forehearth designs, taking the best of both concepts to produce a hybrid design – the 340S.

Two important features of the original Emhart Glass 340 forehearth form the basis of the current 340S design:

- The shape of the superstructure, which features the refractory baffles protruding downwards from the roof, which were first introduced in 1984 in the 540 forehearth. These baffles effectively divide the superstructure into three longitudinal sections to provide separation between cooling in the central area of the channel and heating at the channel edges.
- The unique double cooling system that utilises both direct and indirect air cooling systems, thus increasing cooling capacity and improving controllability.

Other important aspects of the new forehearth design originate from the SORG® STF Series, and these include the gas heating system and channel design. Detail changes made to the air cooling systems are also based on STF technology. The 340S is available for channel widths of 36”, 42”, 48”, 54” and 60” and is now the standard SORG® forehearth design for the majority of applications, particularly for containers. The 240 forehearth is available for less demanding applications and forehearth widths of 16” and 26”.

**ADDITIONAL SYSTEMS**

Several additional systems developed for use with SORG® forehearths can also be used with X40 installations. These include the forehearth CONTI-DRAIN® (see page 24), electric boosting systems for the equalising section (see page 22) and stirrer units.
Developed on the basis of extensive physical modelling, the SORG® coloring forehearth provides optimum color homogeneity over a wide range of operating conditions.

The color concentrate or frit is metered by a gravimetric feeding device and deposited at one or more locations on the glass surface at the beginning of the coloring system.

For installations with throughputs of up to about 70 t/24 h the main mixing is done by two large-diameter, four-paddle stirrers, installed in-line at the start of the mixing area. A system with two skimmer blocks and a wall forces the glass in a vertical direction through the stirrers. Additional mixing is provided by two banks of spiral stirrers that also act as brakes to slow down the fastest forward current, effectively increasing the time available for natural mixing of the colored glass.

**ADVANTAGE**

- Flexible production for special markets.
For forehearts with larger tonnages, mixing occurs exclusively via spiral stirrers arranged in multiple rows.

A CONTI-DRAIN® in the stirrer zone helps speed up removal of colored glass during a color change.

To prepare glass for the production process, conventional cooling and conditioning zone are necessary after the stirrers.

COLORS
The colors that can be made on the SORG® coloring forehearth depend on the availability of color agents. Usually color concentrates or coloring frits/pellets are used. Because the chemical composition and the redox number of the base glass is important, coloring tests with original cullet should be carried out.

The following colors have been successfully produced in SORG® coloring forehearts:

- Eco flint
- All blue tones
- All green tones
- Gray
- Pink
- Violet
- Black

OPERATION
The times needed to change from flint to color and vice-versa depend on many factors. Typical coloring times are from 2-4 hours. De-coloring takes from 8-16 hours. Through the use of the above mentioned drain, these times can be shortened.

A typical lifetime of the stirrers would be about 3 months of actual coloring time.
GAS HEATING SYSTEMS
REGULATED HEAT OUTPUT WITH INTELLIGENT CONTROLLING

The amount of heat supplied is adjusted using a valve to vary the air pressure, and therefore the quantity of air supplied. This automatically varies the amount of gas supplied, and thereby the heating effect.

THE SORG® VMC-SYSTEM
The VMC gas heating system works on the basis of a quantity measurement in both the air and gas lines.

Metering orifice units are installed in the air and gas supply lines to monitor the respective flow quantities. Both signals are fed to the VMC gas control valve in the gas supply line, which adjusts the gas flow to give the required air/gas ratio. Any change in the air flow results in an immediate equivalent adjustment of the gas flow. The air/gas ratio maintained by the system can be varied by adjusting the size of the metering orifice in the gas line. A simple mixer is installed to provide effective mixing of the gas and air. The VMC system conforms to the strict and current EN746-2 regulations.

ADVANTAGES

- Wide working range
- Stable air/gas ratio over the complete working range
**AIR/GAS CONTROL STATIONS**
The air control valves with optional bypass, air/gas mixers, gas control valves, non-return valves in the gas supply line to each individual zone, gas filter and two gas safety valves, are normally installed together in an air/gas control station. The equipment for all the heating zones of one forehearth can be combined in a single station or for each heating zone.

**SPLIT LEFT/RIGHT HEATING**
On a standard forehearth the heating of the left and right sides are coupled together and controlled simultaneously as one control loop, usually based on a temperature reading made in the center of the channel. However, on some installations the glass temperature may be quite different on the two sides of the channel, possibly as a result of a corner in the channel. If this is to be expected, it is possible to separate the left and right heating within a zone and to measure and control temperature individually. The separated heating can be implemented in any number of zones in the distributor and forehearts according to the need.

**THE OXYGEN TRIM SYSTEM OMT**
The VMC gas heating system used on all SORG® forehearths will maintain an accurate air/gas ratio at all times. However, there are situations when it is very useful if the ratio can be checked and adjusted easily. Some heavily reduced glasses are more susceptible to thermal reboil, and it may be necessary to keep the oxidation level of the gas heating as low as practically possible. With many coloring forehearths, a precise control of the atmosphere is necessary in the melting zone. The patented SORG® OMT oxygen trim system is ideal for this application.

The air/gas mixture supplied to the burners is burnt in a special combustion chamber on the forehearth, and the waste gases from the combustion are passed over a zircon oxide oxygen sensor. The sensor signal is passed to a transmitter and on to a ratio controller. An air bleed line and a control valve are used to add a small amount of air to the air/gas premix downstream of the main air/gas mixer. This bleed air supply is varied by the control valve to modify the air/gas ratio according to the output of the ratio controller.

The system not only provides additional security in terms of accurate maintenance of the required air/gas ratio, it also permits easy and accurate adjustment if regular changes in the ratio must be made.
ELECTRICAL HEATING SYSTEMS
LOW CONSUMPTION WITHOUT EXHAUSTS

There are basically two ways in which electricity can be used for forehearth heating.

- Electrodes are inserted directly into the glass and the electricity flows through the glass.
- Electric heating elements are placed above the glass surface.

DIRECT ELECTRODE HEATING
Molybdenum electrodes are used for most applications. The electrodes can be installed vertically through the channel bottom or horizontally through the side walls, but experience has shown that horizontal installation through the side walls gives the best results.

ADVANTAGES OF DIRECT ELECTRODE HEATING
- Low energy consumption
- Fast control reaction range
Long electrodes can be installed at a certain distance from one another so that the current flows from one electrode to the next along the length of the channel. Alternately, short electrodes can be installed along both sides of the channel, so the current flows straight across the channel from one side to the other.

In all cases power for the electrodes is provided by several small to medium transformer units, the number and size of which depend on the electrode arrangement. Stepless variation of the voltage supplied by each transformer is provided by individual thyristor units.

The electrodes are divided into control zones, and in many cases more than one transformer is used in each zone. The system is specifically designed to give very low carry-over voltage values in the spout bowl during normal operation, in order to avoid arcing at the shear blades. In addition, a safety earthing function is provided for use in the bowl area.

Sometimes a small amount of cooling air is blown onto the outside of the electrode, but in most cases no cooling is required. In normal operation there is no wear on the electrodes, and no advancement is necessary.

Auxiliary burners are provided to heat up all-electric electrode foreheaths, whereby either gas or light oil may be used. The same burners are then retained for use in case of a long power failure.

Molybdenum electrodes can be used in amber and green soda-lime glasses without causing any problems. However, in some flint soda-lime compositions complex chemical reactions between the glass and the molybdenum electrode may give rise to some blister formation and the occasional production of dark-colored streaks in the glass.

Electrodes can also be used in gas heated foreheaths or working ends for boosting.
ELECTRICAL HEATING SYSTEMS

Radiant heating elements can be installed in the forehearth superstructure above the glass. Two types of high temperature radiant elements are used for this type of application.

SILICON CARBIDE ELEMENTS

These elements are normally used in the form of rods, installed horizontally across the forehearth, spaced at relatively close intervals along it, with the electrical connections along the sides. The elements in a zone are normally connected in parallel, so that the failure of one single element does not disable the complete zone.

The electrical resistance of the elements increases during high temperature operation, a process which is known as “ageing”, and this must be taken into consideration in the design of the electrical equipment. These elements are quite fragile but, once installed, can normally be expected to operate for 2–4 years before replacement becomes necessary.

INDIRECT HEATING WITH RADIANT HEATING ELEMENTS

ADVANTAGES OF RADIANT HEATING ELEMENTS

- Clean operation (no waste gases)
- Lower energy consumption than gas-heated installations
MOLYBDENUM DISILICIDE ELEMENTS
These heating elements are available in the form of elongated “U”s or “W”s, which are normally hung vertically through the superstructure roof. This means that a forehearth must have a relatively high superstructure in order to allow sufficient height for the elements. Under some circumstances the elements may also be installed horizontally, suspended from the roof at several locations. These elements are ideally suited for installation in a working end or forebay, where the superstructure is normally higher than in a forehearth.

With this type of element a supply of purge air must be provided around the connections to avoid the accumulation of condensate from the glass.

This material has a low electrical resistance, and so element currents are quite high. These elements are also relatively fragile but, once installed, their lifetime can normally be expected to exceed 5 years.

ELECTRICAL EQUIPMENT
Each control zone is provided with a separate main contactor or circuit breaker, so it can be switched on and off independently of all other zones.

All power transformers used on SORG® electrically heated installations are double-wound transformers to provide a galvanic separation of the installation from the supply network. In addition to the normal electrical fusing, each transformer is equipped with two cold-resistance temperature sensors, which cause the transformer to be switched off automatically if it becomes too hot.

All electrical equipment is designed, installed and tested according to the current European harmonized standards.
Almost all cooling systems used in the glass conditioning process rely on heat transfer by radiation, which takes place from a hotter body – the glass bath – to a cooler body, usually either the surroundings or part of the refractory roof. A number of different cooling systems are used on SORG® distributors and forehearts, depending on the particular application.

**RADIATION COOLING SYSTEM**

The open radiation cooling system uses the surroundings to absorb heat radiated by the glass. This involves the provision of openings in the superstructure, sized and located according to the planned cooling capacity. The actual heat loss through the opening is varied by the movement of a damper block to adjust the size of the opening.

This type of cooling system offers an extremely high rate of heat extraction, but care must be taken not to overcool the glass bath surface.

**This system is usually applied to:**

- Distributors
- The rear forehearth zone

**ADVANTAGE OF THE RADIATION COOLING SYSTEM**

- High heat transfer rate
DIRECT AIR COOLING SYSTEM

Cooling air is blown directly into the combustion space of the superstructure just below the roof, to cool the roof refractories. Heat transferred from the hotter glass bath by radiation to reheat the roof is therefore removed from the glass.

The amount of heat removed can be adjusted by varying the volume of air blown into the superstructure.

This system is usually applied to:

- The central area of distributors
- 340S and STF forehearths

ADVANTAGE OF THE DIRECT AIR COOLING SYSTEM

- Good controllability
INDIRECT AIR COOLING SYSTEM
The area to be cooled is covered by a thin refractory tile, made of a material with a very good thermal conductivity. A small duct running parallel to the forehearth axis is provided in the superstructure refractory above the tile. When cooling air is blown along this duct, the upper surface of the thin tile is cooled. This reduces the temperature of the lower surface of the tile and energy is removed from the glass bath by radiation to the cooler tile.

The cooling effect is varied by adjustment of the volume of cooling air blown along the duct. This system is easy to control and is extremely stable.

This type of cooling system is usually applied to:

- 240 forehearths
- 340S forehearths
- All-electric forehearths

ADVANTAGES OF THE INDIRECT AIR COOLING SYSTEMS

- No overcooling risk
- Stable operation
**BOTTOM COOLING**

Cooling air is blown through ducts in the substructure refractories below the centre of the channel and aligned with the channel center line. The cooling effect can be influenced by adjustment of the air quantity, but the system is very slow to react and is not suitable for automatic control.

This is basically an indirect air cooling system applied below the channel bottom. The heat must be transferred through the bottom channel block and, as this is in contact with the glass, heat is removed by conduction. This means that it is only removed from a thin layer very near to the channel bottom and, if this becomes too cold, it is almost impossible to reheat it within an acceptable time period.

**ADVANTAGE OF BOTTOM COOLING**

- Only system specifically cooling bottom glass
EQUALIZING SECTION BOOSTING SYSTEMS

THERMIC HOMOGENEITY IN AN EFFICIENT FORM

An electric boosting system in the equalizing section is a simple and effective method of improving the thermal homogeneity.

The electrodes are specially designed for use in forehearths, and consist of a molybdenum inner part attached to a high temperature steel connector. They are installed horizontally through the channel side walls, are naturally air-cooled and do not normally require any additional cooling.

The electrical equipment comprises a number of single phase, double-wound transformers, each with a thyristor unit to give stepless control of the applied power.

ADVANTAGES

- Improved thermal homogeneity
- Easy to use
- Different arrangements possible. (6, 8 or 12 electrodes)
All electrical equipment is installed in totally enclosed sheet steel cabinets, built and tested to current European harmonized EN standards.

The heating circuit can be arranged to heat either the glass at the channel side, or the bottom glass.

All systems feature two special safety functions:

- A special firing pattern that results in a very low carry-over voltage into the bowl
- A safety earthing function that ensures there is absolutely no voltage to earth in the bowl when work is being carried out there

The electrodes are often installed during a cold repair of the forehearth, but they can also be added to an existing line during operation.

The system offers the following advantages:

- direct influence on the glass at the channel sides and/or bottom – areas that are normally difficult to influence
- very quick reaction to adjustments makes it easy for operating personnel to optimize performance
- very low power requirement (normally < 10 kW)
- can be installed on operating forehearths with a minimum of disturbance

These systems are also used for flint colored glasses. For flint glass forehearths, a DC plating system is used to insure no reduction in glass quality.
FOREHEARTH CONTI-DRAIN® SYSTEM
REMOVING CONTAMINATED GLASS

Zircon cords, often known as cat scratches, are an increasing problem for many glass manufacturers. Experience has shown that the zircon rich glass which causes the cords is usually found right on the channel bottom, where it is inaccessible to stirrers.

After extensive model tests and tests under operating conditions, SORG® has developed a version of the patented CONTI-DRAIN® system for forehearths, specifically to remove this contaminated glass.

The forehearth CONTI-DRAIN® system comprises a special channel block together with an electrically heated drain unit.

The channel block features a drain hole at the bottom of a specially shaped well. The block itself is normally fused cast AZS to facilitate operation of the electrical heating system.

ADVANTAGE

- The only system that has consistently reduced or eliminated zircon cord
The drain itself consists of a high temperature resistant steel plate which acts as an outlet nozzle. This is placed up against the underside of the outlet hole in the channel block. A simple ceramic holder assembly is used to keep the metal plate in position and provide electrical insulation. The temperature of the outlet nozzle is measured by a thermocouple.

The electrical heating system comprises a small double-wound transformer with a thyristor unit to provide stepless voltage variation. A temperature controller is used to maintain a constant temperature at the outlet nozzle, which results in a constant flow velocity of the glass. Adjustment of this temperature gives a change in the amount of glass being drained. It is imperative that the glass is drained slowly in a controlled manner.

In most cases, the operating mode is continuous. However, discontinuous operation is also possible, as it is easy to stop and start the drain.

The amount of glass which must be removed depends on a number of factors.

On a new installation or repair, the drain block can be installed without the drain equipment. It is possible to install drain equipment and activate the system at a later date if it becomes necessary.

Under some circumstances it is possible to install a forehearth CONTI-DRAIN® on an existing forehearth with no special channel block by drilling the required profile from outside of the forehearth.

The standard CONTI-DRAIN® system utilises a molybdenum counter electrode in the glass bath. In the case of highly oxidised soda-lime flint glasses this can lead to blister formation and although most of these will be removed by the drain, a few may be found in the production. For these applications we have developed a version of the forehearth CONTI-DRAIN® that does not need a counter electrode.

Experience has shown that the forehearth CONTI-DRAIN® is capable of reducing or eliminating visible zircon cord in the production.
PLEDGE OF SERVICE

SORG® SERVICE
THINGS YOU CAN COUNT ON

By choosing our high quality glass melting furnaces and conditioning systems you get access to our first-class service around the clock. It is our ambition to support your production as reliable and fast as possible.

EXPERIENCE
For over 140 years, we have been providing satisfied customers in over 70 countries with innovative furnaces to melt different glass types. At any one time there are over 600 SORG® glass conditioning systems in operation.

TECHNOLOGY
SORG® technology has been driving the glass industry for decades. Innovations such as our endport furnaces, the Deep Refiner®, VSM® cullet and batch preheating as well as equipment for use under severe conditions speak for themselves. Also in the future we will be emphasizing innovation. The result: Safe investments for our customers with the lowest total cost of ownership.

EXPERTISE
We are specialized in glass melting and conditioning and offer a wide range of services. Over 90 experts are available to offer competent help. They support the process from concept development through operations. On site services compliment our offerings and maintain the quality of our equipment.

GOOD REASONS TO PARTNER WITH SORG®:

- Lowest total cost of ownership
- Minimize technological risk
- First class service
- You profit from our continuing research and development